



# TARDEC



## ***Field Demonstration of Bio-based Hydraulic Fluids for Military Construction Equipment***

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# Outline



- ◆ Background
- ◆ Federal Biobased Products Preferred Procurement Program
- ◆ New Biodegradable/Biobased Hydraulic Fluid Specification
- ◆ Field Demonstration-Final results
- ◆ Conclusions



## Background

- ◆ Hydraulic systems are an essential component of military equipment ranging from aircraft flight control systems, armored vehicle and shipboard hydraulic systems, to depot machine tools
- ◆ Common problems in these hydraulic systems are the potential for leakage and possibility of spillage of hydraulic fluid
- ◆ All military hydraulic fluids were formulated with petroleum or synthetic hydrocarbon base stock, which is not readily biodegradable. So, if spilled, hydraulic fluid may harm the environment and must be cleaned up as a hazardous waste
- ◆ Implementation of Executive Order No. 13134 on Developing and Promoting Biobased Products and Bioenergy
- ◆ U.S. Army has issued a Biodegradable Hydraulic Fluid (BHF) Specification to accept Bio-based Fluids that can be used in existing military hydraulic systems



## Background (continued)

- ◆ Recently, USDA has initiated Federal Bio-based Products Preferred Procurement Program to procure bio-based products including hydraulic fluids for Federal Agencies.
- ◆ This program provides preferred procurement by all Federal agencies of qualifying bio-based products that meet the performance criteria of procurement standards.
- ◆ Functional Performance is an essential criterion for usage of bio-based products in existing hydraulic systems.
- ◆ In cooperation with USDA, a field demonstration was initiated at Fort Leonard Wood to verify performance of biobased hydraulic fluids in military construction equipment.



# Projected Benefits for Biobased Fluids

- ◆ Reduce hazardous waste by natural recycling
  - Reduce petroleum hydrocarbon contamination in landfill
  - Preserve ground water and soil
  - Reduce disposal costs of hazardous waste
  - Reduce clean up costs of soil and ground water
- ◆ Reduce petroleum consumption
- ◆ Alternative lubrication resource
- ◆ Accomplish P2 program
- ◆ Others



# USDA Federal Biobased Products Preferred Procurement Program



- ◆ Implement Section 9002 of Farm Security and Rural Investment Act of 2002.
- ◆ Provide information about availability , price, performance, environmental and public health benefits, life cycle costs, and recommended biobased content.
- ◆ Require that biobased products must be manufactured with raw materials or wastes from domestic agricultural production or feed stock from trade agreement - farming, ranching, forestry, aquaculture.
- ◆ Certify biobased products
- ◆ Web site: [www.biobased.oce.usda.gov](http://www.biobased.oce.usda.gov)



# BIOBASED PRODUCTS LIST

## ◆ Broad Categories of Products

- Solvents, cleaners
- Plastics
- Paints, coatings
- Construction materials/composites
- Adhesives
- Fuel additives
- Inks
- Sorbents
- Packaging
- Landscaping materials, composted livestock and crop residue
- Lubricants/functional fluids



# CRITERIA FOR PRODUCTS TO BE DESIGNATED BIOBASED



## ◆ 1. BIOBASED CONTENT

- Products must be manufactured with raw materials or wastes from domestic agricultural production – farming, ranching, forestry, aquaculture
- Minimum content
  - » By category (item)
  - » Verified by ASTM methodology using  $^{14}\text{C}$  dating

## ◆ 2. PERFORMANCE AND SPECIFICATIONS

## ◆ 3. ENVIRONMENTAL PERFORMANCE/LIFE CYCLE

- National Institute of Standards and Technology “Building for Environmental and Economic Sustainability” (BEES) program  
[www.bfrl.nist.gov/oae/bees.html](http://www.bfrl.nist.gov/oae/bees.html)



# FIRST ITEMS TO BE DESIGNATED BIOBASED



## ITEM

## Minimum biobased content

hydraulic fluids (mobile equipment) 44%

penetrating lubricants 68%

diesel fuel additives 90%

urethane roof coatings 20%

bedding, bed linens, and towels 12%

water tank coatings 59%

**Qualifying products must be given preference by all Federal agencies**

**Manufacturers can post their product info on website:  
[www.biobased.oce.usda.gov](http://www.biobased.oce.usda.gov)**

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# New Biodegradable/Biobased Hydraulic Fluid Specification, MIL-PRF-32073



- ◆ Specification originally designed for use in construction equipment, bridging, some tactical vehicles, shipboard hydraulic systems, and metal tool applications, etc.
- ◆ Specification requirements developed based on specific military needs and current BHF formulation technology.
- ◆ It consists of five grades based on ISO viscosity ranges and covers all types of biobased hydraulic fluids derived from renewable resources.
- ◆ Biodegradation test uses ASTM D 5864, Aerobic Aquatic Biodegradation Test Method and OECD toxicity Test.
- ◆ Specification requires qualification inspection and has Qualified Product List (QPL).
- ◆ No limit on concentration of biobased material, performance is driver.

PERFORMANCE SPECIFICATION  
HYDRAULIC FLUID, BIODEGRADABLE

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers biodegradable hydraulic fluids for use in environmentally sensitive areas (see 6.1).

1.2 Classification. Hydraulic fluids are of the following grades (see 6.2):

- Grade 1 – ISO VG 15
- Grade 2 – ISO VG 22
- Grade 3
- Grade 4 – ISO VG 46
- Grade 5 – ISO VG 68

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of the list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-D/210, Warren, MI 48397-5000, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.



# Field Demonstration

- ◆ Field tests initiated using ten pieces of construction equipment ( i.e., Crane, Bulldozer, Scraper, Grader, Loader, Excavator, etc.) at Fort Leonard Wood, MO.
- ◆ Five (5) BHF's qualified under MIL-PRF-32073 Biobased hydraulic fluid specification selected as field demonstration samples.
- ◆ Evaluation criteria used in this demonstration are their field operational performances and vehicle system compatibility such as seal leaking, and field sample evaluation.
- ◆ Duration of tests was designed for one (1) year.
- ◆ Cooperate with PM of Construction Equipment and TARDEC Construction Team.
- ◆ If field demonstration successes, fluids will be permanently introduced into military system



# Biobased Hydraulic Fluids for Field demonstration (MIL-PRF-32073)

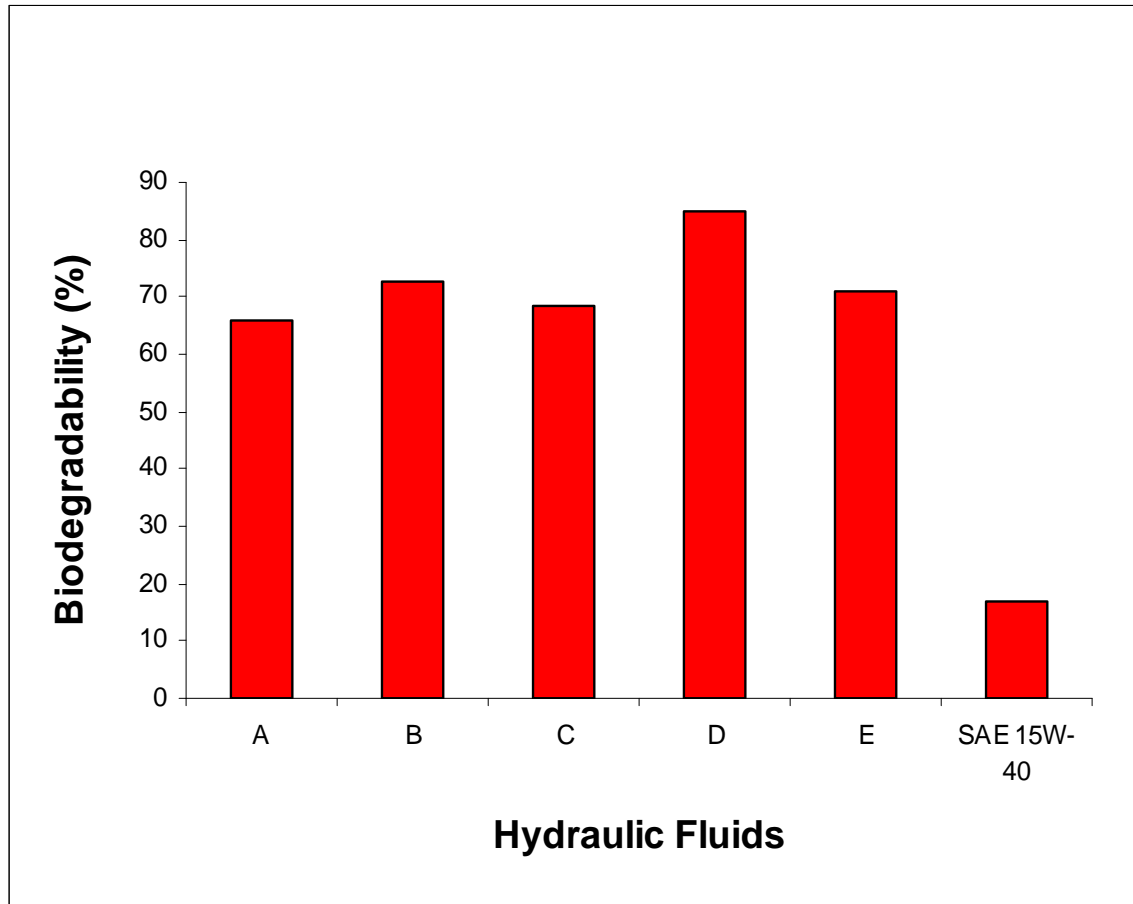


Code	Product name	Viscosity @40 °C	Pour point	Spec Grade	QPL Number	Company
A	Cognis Proeco EAF 422 LL	22.6	-51	2	BHF-01	Cognis
B	Novus 100 ISO 46	42.0	-44	4	BHF-02	Cargill
C	Hydro Safe ISO VG68M5	68.6	-37	5	BHF-07	Hydro Safe
D	Terresolve EL 146	46.6	-25	4	BHF-08	Terresolve
E	Hydro Safe ISO32M3B	40.3	-35	3	BHF-09	Hydro safe

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# Biodegradability of Hydraulic Fluids





# Field Demonstration Procedure



- ◆ **Fluid change over procedure**
  - Operate vehicle for 15-20 minutes in order to warm the system.
  - Drain existing fluid from reservoir and total system such as pumps, lines and hoses.
  - Refill system with biobased fluid and again operate system for 15-20 minutes.
  - At the end of the second warm-up period, drain and replace fluid with a fresh change of new fluid.
- ◆ **Set up duplicate test for each fluid to increase reliability of test.**
- ◆ **Inspect vehicles (i.e., leaking, fluid level, power, etc) and record operation hours , and collect field samples for laboratory evaluation at each quarter of the testing period.**
- ◆ **Complete field demonstration after a year.**



# Test Protocol for Laboratory Evaluation



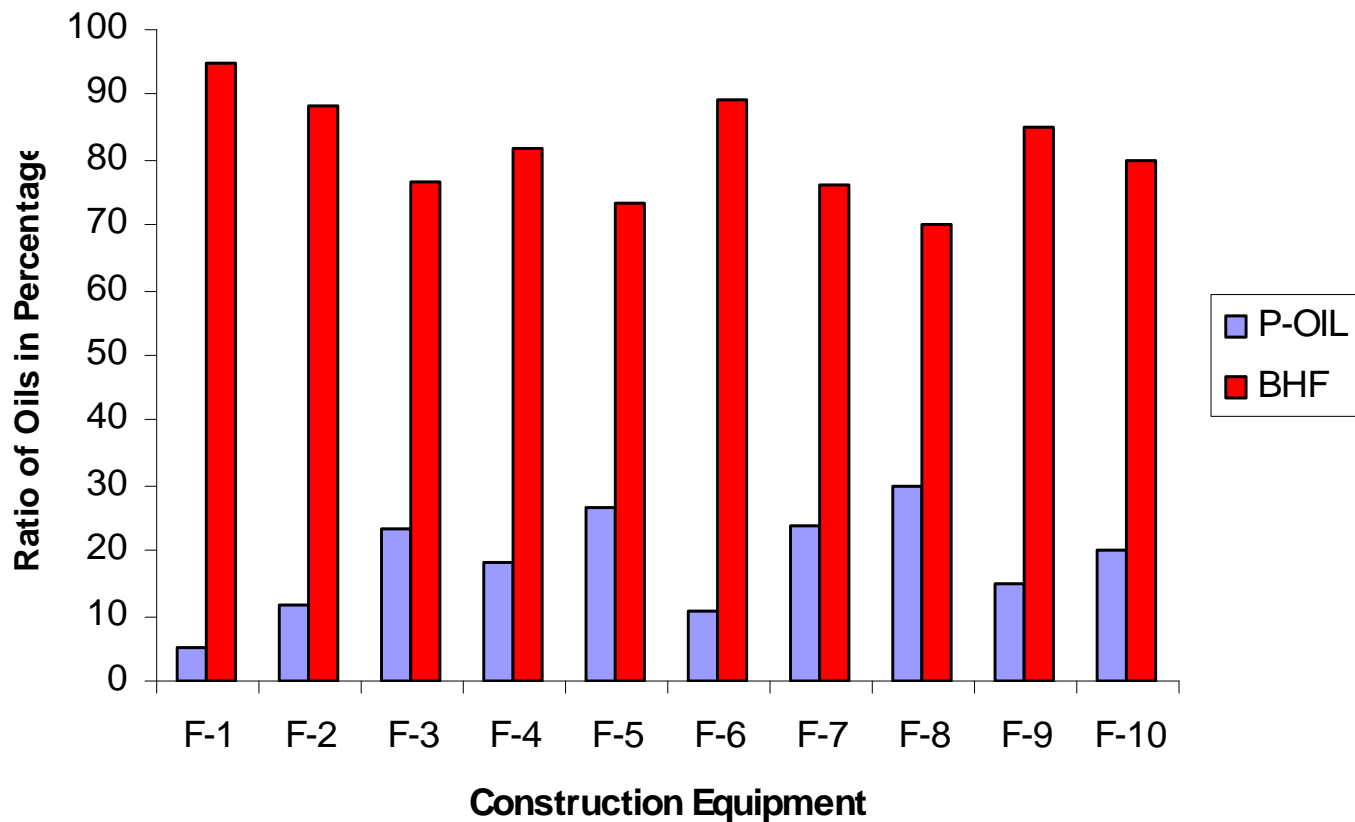
Test	Method
Viscosity	ASTM D 445
Water content	ASTM D 6304
Oxidation Stability	ASTM D 6186, ASTM D 664
Evaporation	ASTM E 1131
Low temperature Stability	ASTM D 6351
Elemental Analysis	X-ray Technique
Composition Analysis	ASTM Draft Test Method





MINISTRY OF PETROLEUM & WATER  
BUSINESS AREA

## Field Sample - Petroleum Product Residue



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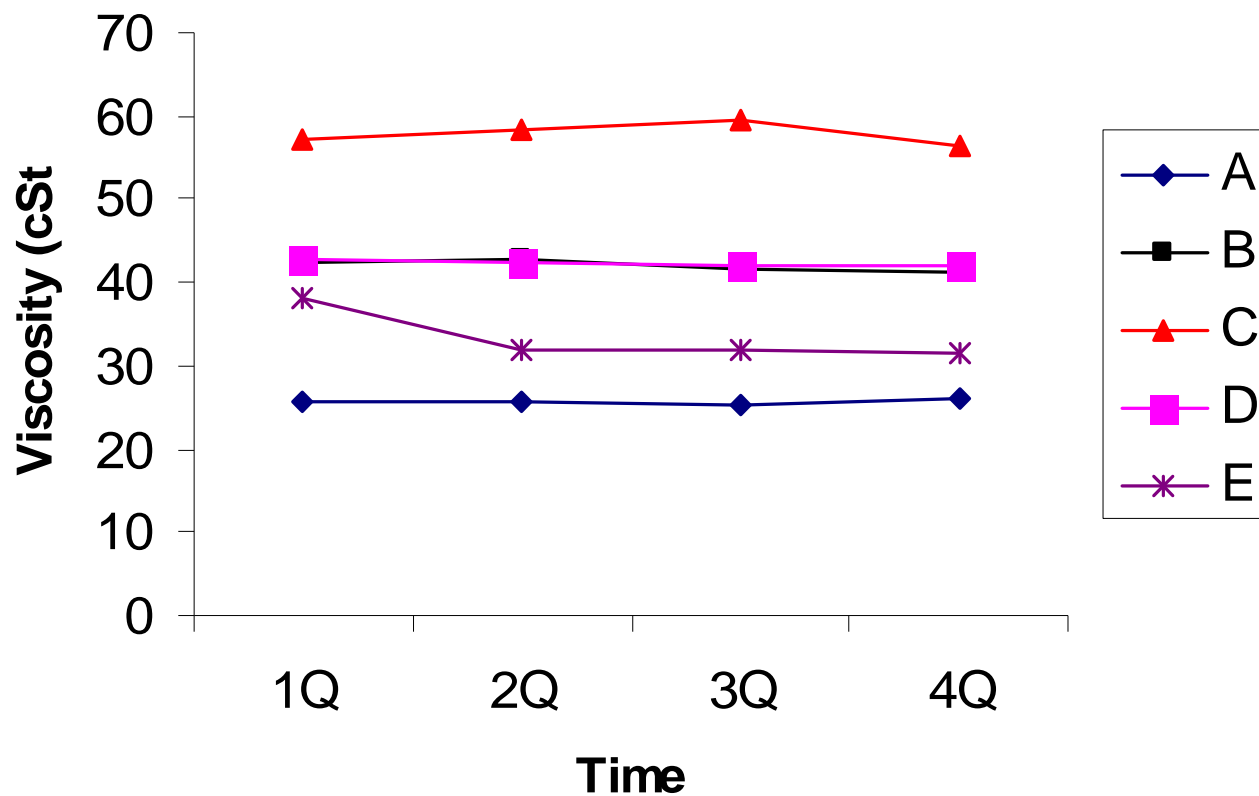




# Field Test Results

Code	Name	Equipment Usages (hr)	Test oil	Leaking or other problems	Fluid condition (visible inspection)	Oil degradation by PDSC test (%)
F-1	Bulldozer	276	A, Red	No	Good	8.4
F-2	Bulldozer	258	D, Green	No	Good	9.8
F-3	Scraper	312	D, Green	No	Good	0.5
F-4	Scraper	286	E, Orange	No	Good	2.8
F-5	Grader	196	E, Orange	No	Good	12.2
F-6	Grader	393	A, Red	No	Good	9.9
F-7	Loader	272	E, Orange	No	Good	0.01
F-8	Excavator	157	B, Blue	No	Good	53.8
F-9	Crane	135	B, Blue	No	Good	27.1
F-10	Crane	244	C, Yellow	No	Good	23.6

## Viscosity Profile of Tested Fluids





# Summary of Laboratory Evaluation (1)



- ◆ No significant viscosity changes observed in any construction Equipment.
- ◆ All samples showed some degree of oxidation, but still have good conditions.
- ◆ None of fluids had Low Temperature Operational Problem at Midwest Winter Weather (subzero to -30 °C).
- ◆ BHF's had good hydrolytic stability that resists reaction with water.
- ◆ Equipment had no leaking problem, seals look good



# Summary of Laboratory Evaluation (2)



- ◆ BHF's did not give any volatility problem during demonstration.
- ◆ No evidence for incompatibility between BHF's and structural materials used in hydraulic systems.
- ◆ No Biodegradation occurred in hydraulic systems.
- ◆ Environment property of fluids (i.e., biodegradability) did not change throughout demonstration.
- ◆ No incompatibility was observed between bio-based fluids and petroleum based fluids.



# Conclusions

- ◆ Field demonstration completed using five MIL-PRF-32073 biobased fluids and ten types of construction equipment at Fort Leonard Wood, MO.
- ◆ Field Test results indicate bio-based fluids did not show any abnormal behavior nor incompatibility with hydraulic systems such as oil leaking or operational problem.
- ◆ In addition, laboratory results from field samples indicated only standard degradation during demonstration period as compared to petroleum products.
- ◆ Bio-based fluids are compatible with existing petroleum based fluids. Fluids can be interchanged without major cleaning effort.
- ◆ Bio-based fluids can be used in military construction Equipment. Performance is the same as Petroleum based fluids.



# Recommendations

- ◆ Use Bio-based fluids as military operational fluids for construction Equipment.
- ◆ Conduct extended field demonstration to determine service life of bio-based fluids in construction Equipment.
- ◆ Consider a study to convert waste bio-based fluid to a fuel
  - Fuel produced must meet appropriate specification. Biofuels generated need to be evaluated to ensure equipment compatibility.